California High-Speed Train Project

TECHNICAL MEMORANDUM

Geotechnical Reports Preparation Guidelines
TM 2.9.2

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0	20 May 09	Initial Release
1	03 Jun 11	Addresses TAP Comments

Note: Signatures apply for the latest technical memorandum revision as noted above.

Prepared by PB

for the California High-Speed Rail Authority

System Level Technical and Integration Reviews

The purpose of the review is to:

- Ensure technical consistency and appropriateness
- Check for integration issues and conflicts

System level reviews are required for all technical memorandums. Technical Leads for each subsystem are responsible for completing the reviews in a timely manner and identifying appropriate senior staff to perform the review. Exemption to the System Level technical and integration review by any Subsystem must be approved by the Engineering Manager.

System Level Technical Reviews by Subsystem:

Systems: Not Required____________________ ____________
Rick Schmedes Date

Infrastructure: Signed document on file_____________ 20 Jun 11 _____
Bob Valenti Date

Operations: Not Required____________________ ____________
Joe Metzler Date

Maintenance: Not Required____________________ ____________
Joe Metzler Date

Rolling Stock: Not Required____________________ ____________
Frank Banko Date

TABLE OF CONTENTS

ABSTRACT

This technical memorandum addresses reporting of geotechnical information for phased design and construction of California High-Speed Train Project infrastructure facilities. The geotechnical reports will present the findings of the geotechnical investigations and analyses that are performed during preliminary and final design. The term geotechnical report refers to all design level geotechnical reports, including the geotechnical data report, geotechnical baseline report, and geotechnical design report. These reports will be the basis for geotechnical-related aspects of design and construction of project features including earthwork, foundations, and underground infrastructure facilities.

This technical document presents recommended guidelines for the information to be included in the following reports:

- Geotechnical Data Report
- Geotechnical Baseline Report
- Geotechnical Design Report

Additionally, this technical memorandum provides guidance on the content and format of the reports, including the following:

- Checklist of items to consider
- Recommendations for the content and wording of baseline statements
- Examples of problematic and improved practice in stating geotechnical baselines

This document is intended to improve the clarity, understanding, and usefulness of these reports and to promote compatibility and consistency between the geotechnical reports and other contract documents. The guidelines for the preparation of geotechnical reports for the California High-Speed Train Project consider the design-build approach that will be implemented for project procurement and delivery.

1.0 INTRODUCTION

Geotechnical reports are the primary tools used to communicate the site and subsurface characterization conditions as well as design and construction recommendations to the design and construction personnel. The information contained in the geotechnical reports is referred to frequently during the design period, construction period, and even after completion of the project in resolving claims or for operational issues that are geotechnical-related. This technical memorandum (TM) describes the link of geotechnical reports with other contract documents, including risk registers, design plans, and specifications in order to ensure compatibility between these reports and other contractual documents for the project.

In order to provide a consistent and dependable design, it is important that the project use standardized reporting and documentation practices and procedures across the project segments. This uniformity and consistency for geotechnical documents will facilitate interface and sharing among technical/design teams throughout the design and construction stages of the project. Geotechnical reports will be prepared by knowledgeable personnel with considerable geotechnical, geological, design, and construction experience relevant to the project. The guidance for phased geotechnical reports considers the design-build (D-B) approach to be used for implementation of project procurement and delivery for the California High-Speed Train Project (CHSTP).

1.1 PURPOSE OF TECHNICAL MEMORANDUM

The primary purpose of preparing geotechnical reports is to establish single-source documents that provide design-level information and recommendations as well as describe the geotechnical conditions anticipated (or to be assumed) to be encountered during subsurface construction. For the D-B project delivery method, the contractual statements included in the report type termed the geotechnical baseline report (GBR) are referred to as baselines. The principal purpose of the GBR is to set clear realistic baselines for conditions anticipated to be encountered during subsurface construction, and thereby provide D-B bidders with a single contractual interpretation that can be relied on in preparing their bids. Other important objectives of the GBR are to:

1. Discuss the site and subsurface conditions related to the anticipated means and methods of constructing the geotechnical-related elements of the project
2. Present the geotechnical and construction considerations that formed the basis of preliminary design for the subsurface components and for specific requirements that may be included in the specifications
3. Enhance the understanding of the key project constraints and important requirements in the contract plans and specifications that need to be identified and addressed during bid preparation and construction
4. Assist in evaluating the requirements for excavating and supporting the ground
5. Guide the administration of the contract and monitoring performance during construction

1.2 GENERAL INFORMATION

For this TM, efforts have been made to present the general state of the practice of geotechnical report preparation. The information is based predominantly on an established reference publication by the American Society of Civil Engineers (ASCE), specifically the reference titled “Geotechnical Baseline Reports for Construction – Suggested Guidelines,” (ASCE 2007). This reference provides generally accepted (standardized) guidelines for geotechnical reports used for engineering design and construction purposes on major heavy-civil works projects. However, the information in this TM extends and, in some cases, modifies the standards for geotechnical reports to include additional criteria specific to the high-speed train (HST) project.

According to the ASCE guidelines, "… *it is recommended that a single interpretive report be included in the contract documents and be called a Geotechnical Baseline Report (GBR). The GBR should have both design-related issues (basis for design) and construction issues as the primary points of focus. This will serve to establish clarity of focus as to why the reports are prepared, how they will be used, and how they should be written. The GBR is actually more than a collection of baselines. This report is the primary contractual interpretation of subsurface conditions and the report should discuss these conditions in enough detail to accurately communicate these conditions.*"

1.2.1 Definition of Terms

The following technical terms and acronyms used in this document have specific connotations with regard to the California High-Speed Train (CHST) system.

Acronyms

AREMA	American Railway Engineering and Maintenance of Way Association
ASCE	American Society of Civil Engineers
Caltrans	California Department of Transportation
CEG	Certified Engineering Geologist
Authority	California High-Speed Rail Authority
CHST	California High-Speed Train
CHSTP	California High-Speed Train Project
CPT	Cone Penetration Test
D-B	Design Build
DSC	Differing Site Conditions
EPB	Earth Pressure Balance (for Tunnelling)
FHWA	Federal Highway Administration
FRA	Federal Railroad Administration
GBR	Geotechnical Baseline Report
GBR-B	Geotechnical Baseline Report for Bidding
GBR-C	Geotechnical Baseline Report for Construction
GDR	Geotechnical Data Report
GE	California-registered Geotechnical Engineer
GTGM	FHWA Geotechnical Technical Guidance Manual
LOTB	Logs of Test Borings
MPH/mph	Miles per hour
NEHRP	National Earthquake Hazards Reduction Program
NIST	National Institute of Standards and Technology
SPT	Standard Penetration Test
TBM	Tunnel Boring Machine
TM	Technical Memorandum

1.2.2 Units

The CHSTP is based on U.S. Customary Units consistent with guidelines prepared by the California Department of Transportation and defined by the National Institute of Standards and Technology (NIST). U.S. Customary Units are officially used in the United States, and are also known in the U.S. as "English" or "Imperial" units. In order to avoid any confusion, all formal references to units of measure should be made in terms of U.S. Customary Units.

2.0 DEFINITION OF TECHNICAL TOPIC

2.1 GENERAL

The focus of phased geotechnical reports that provide input for design, construction, and long-term maintenance support is to ensure that the soil and/or rock beneath the ground surface can accommodate the conditions placed on it by HST infrastructure facilities. This includes project elements such as support of loads from major structures or earthwork (embankment fills) and significant slope cuts in rock or soil, as well as major excavations for underground segments including tunnels.

The geotechnical investigations for the project definition phase will be performed to provide recommendations for conceptual alignments and feasibility studies and for the development of project cost estimates. Geotechnical investigations during preliminary engineering are required to validate the preferred alignment, establish the location and type of aerial or underground guideways, prepare construction cost estimates, and support design-build bidding. Supplemental geotechnical investigation activities will be necessary for the final engineering design phases. Key components of the geotechnical design for the preliminary design phase of the project include investigations to identify potential fatal flaws with the project alignment, potential constructability issues, and geotechnical hazards such as earthquake sources and faults, liquefaction, landslides, rockfall, and soft ground. Geotechnical design shall provide conceptual hazard avoidance or mitigation plans to address the identified geotechnical issues. An assessment of the effect geotechnical issues have on construction staging, project constructability, cost, and schedule can be made at this time.

2.1.1 CHSTP Design Considerations

For the design phases, once the preliminary project elements and alignments are established, the geotechnical designer will assess feasible foundation types, cut and fill slopes, retaining wall types, etc., to establish the final right-of-way and easement needs for the project. The phased geotechnical memorandums and reports will include preliminary recommendations as well as special provisions and plan details to incorporate the geotechnical design input to the D-B design plans and documents prior to D-B bidding and then final design criteria during D-B delivery.

2.2 LAWS AND CODES

There is no existing law, code, or design standard that can be followed in the development of geotechnical reports. The Federal Railroad Administration (FRA) does not regulate the preparation of geotechnical reports, and the European Technical Specifications for Interoperability (TSI) do not define requirements for preparing geotechnical reports.

The development of the geotechnical baseline report requirements was based on a review and assessment of available information, including but not limited to the following:

1. American Society of Civil Engineers (ASCE) reference titled "Geotechnical Baseline Reports for Construction – Suggested Guidelines," ASCE 2007
2. FHWA's Checklist and Guidelines for Review of Geotechnical Reports and Preliminary Plans and Specifications, FHWA-ED-88-053, 1988, revised February 2003
3. Guidelines for Preparing Geotechnical Design Reports, version 1.3 December 2006 by Caltrans
4. Guidelines for Structures Foundations Reports, version 2.0 March 2006 by Caltrans

A listing of references considered in preparation of this memorandum is included in Section 5.0.

2.3 APPLICABILITY TO RISK REGISTERS AND OTHER CONTRACT DOCUMENTS

Risk registers will be used during design of the HST project. The GBR-type report containing the geotechnical baselines will include discussion of risk register evaluations. By its nature, the risk register process addresses a much broader range of risks than those addressed in a GBR and discusses specific mitigation strategies. For the HST project, the outgrowth of such mitigation strategies will be incorporated in the design, selection of project alignment and construction methods, etc. There is a logical connection between the identification of geotechnical aspects that could present risks to a project and the need to address such items in a GBR. As such, the risk register and GBR are complementary. The risk register process identifies, among other items, key geotechnical, construction, and third-party risks. The GBR has the opportunity to provide a contractual platform for describing how certain risks have been addressed in the planning and design and how other risks are to be allocated and managed during construction.

It is recommended that a draft GBR be written after most of the preliminary design work has been completed, whether under traditional design-bid-build or D-B procurement. During the site exploration and preliminary design phase, risk registers will be utilized to identify key issues. As site exploration, project planning, and detailed design are advanced, certain risks will be identified that are associated with geotechnical and other subsurface conditions. It is precisely those conditions associated with the greatest perceived risks that should be addressed specifically in the GBR. The risk register document will not be included in the GBR.

Baseline statements in the GBR should be consistent with the design, anticipated construction methods, and measurement and payment provisions in the preliminary drawings and specifications. All possible conditions and circumstances that may be encountered cannot and do not need to be included in baseline statements and addressed by measurement and payment provisions. For some conditions, it may be impossible to establish methods of measuring quantities against which payment provisions may be applied.

3.0 ASSESSMENT AND ANALYSIS

By considering the geotechnical reports, participants to the project are provided with an understanding of the key project geotechnical issues and constraints that have shaped the design and construction requirements. With this background, they are better prepared to understand the rationale behind the requirements of the drawings and specifications, and better prepared to offer innovative ideas for improvements in the form of value engineering change proposals. In some cases, an accepted value engineering change proposal could warrant a modification to the baseline(s) in the geotechnical reports.

The geotechnical reports will represent the culmination of investigations and analyses that are performed in accordance with geotechnical investigations, geologic and seismic hazards evaluations, tunneling investigation and design, and ground motion analyses. As these are inter-dependant, it will be essential that these report documents are available and reviewed by the project geotechnical engineer. These reports will be the basis for design and construction of earthwork and foundation features, and major underground structures in tunnel reaches for infrastructure facilities.

3.1 GENERAL REQUIREMENTS FOR GEOTECHNICAL REPORT TYPES

Geotechnical Baseline Report (GBR-B) - The GBR-B will be limited to interpretive discussion and baseline statements and will make reference to, rather than repeat or paraphrase, information contained in the GDR, or preliminary drawings or specifications. Further discussion of the content and format of phased GBR-Bs is described later in this document. In addition to the need for a close link to other contract documents, the GBR-B offers the opportunity to provide an overview of the project so that what is contained in the other documents is easier to understand. The GBR-B provides a platform to explain the why, i.e., the rationale and basis for items detailed elsewhere. Baseline statements in the GBR-B should be consistent with the design, anticipated construction means and methods, and measurement and payment provisions in the drawings and specifications. A careful balance must be sought between providing a document that can be readily absorbed by a bidder without the benefit of having reviewed the other contract documents, and paraphrasing the other Contract Documents to the degree of creating ambiguity or contradiction. An important objective for the GBR-B is to produce a concise document that can be read and understood in less than about four hours. A maximum length of 40 to 50 pages of text is recommended for the project segments. The document must not be too long as to make it difficult to ferret out the baselines. GBR-B preparers are cautioned to avoid overly long or complex descriptions of physical conditions or behaviors. Extended geologic descriptions and details should be limited to the GDR. Emphasis will be directed to those physical conditions or behaviors that will most influence the means and methods of construction, construction costs, or critical equipment to be utilized.

Geotechnical Data Report - The designer's geotechnical engineer will develop the GDR document, and contains the factual information that has been gathered during the initial exploration and conceptual preliminary design phases of the project. The GDR should contain the following general information:

- A description of the geologic and hydrogeologic (groundwater) settings
- A description/discussion of the site exploration program
- The logs of all borings, trenches, and other site investigations
- A description/discussion of all field and laboratory test programs
- The results of all field and laboratory testing

The GDR will be included as a Contract Document. In the event of conflict or ambiguity, the GBR will be given precedence over the GDR within the Contract Document hierarchy. In the event that the GBR is silent on a particular circumstance, the GDR should be reviewed to see if there is any

data/information relevant to the issue in question. Further discussion of the content and format of GDR is described in Section 6.1.2.

Geotechnical Memoranda for Preliminary Design - An interpretation of the available geologic data is often needed within the design team well in advance of the preparation of a GBR. Following completion of preliminary site exploration activities and preparation of a draft GDR, the geotechnical engineer may prepare draft memorandums for D-B-level designs that address a broad range of issues for the project team's internal consideration. The interpretive memos for preliminary design may be used to:

- Comment on and discuss the data
- Present one or more initial interpretations of the data
- Evaluate the limitations of the data and discuss additional data needs
- Present an evaluation of how the subsurface conditions would affect alternative approaches to project design and construction
- Evaluate project risks as a function of alternative construction approaches
- Assess any construction impacts on adjacent facilities
- Provide geotechnical design criteria for both permanent and temporary subsurface structures

The discussions may appropriately address broad ranges of anticipated conditions to indicate the level of certainty (or uncertainty) in these judgments. Such discussions are not appropriate as baselines. The memos may discuss design and construction alternatives that are subsequently judged of unacceptably high risk to the Authority or third parties, and are thus eliminated from further consideration and not addressed in the GBR. Because of the differences between the preliminary interpretive memos and the GBR, it is recommended that titles be given to the memos that clearly portray intent and timing within the design process, e.g., "Draft Geotechnical Memorandum," or "Draft Geotechnical Memorandum for Preliminary Design." Although the document must be disclosed to bidders as available information, it should not be a part of the Contract Documents. The memos will include specific introductory statements that they are preliminary documents not to be used for final design or construction purposes and that interpretations and discussions presented therein will be superseded by subsequent interpretations and baselines in the GBR. Depending on the design approach and the number of design iterations that occur during the design process, multiple geotechnical memoranda, or amended or revised versions of the memoranda, may be produced. The GBR should be the only interpretive report that is included in the contract documents.

Final Geotechnical Design Reports - Final geotechnical design reports by the D-B team's geotechnical engineer are generally developed based on an office review of existing geotechnical data for the site, a detailed geologic and hydrogeologic review of the site, and a final subsurface investigation program meeting project standards. The detail contained in each section of the reports for final design will depend on the size and complexity of the project elements and subsurface conditions. Further discussion of the content and format of final geotechnical design reports is described in Section 6.1.3.

Data and information that has been obtained in the course of the initial site characterization effort will be assembled and disclosed in an organized fashion with standard format geotechnical reports for the D-B bidders. This geotechnical information will be incorporated in the Contract Documents, so that the D-B teams have an appropriate database upon which to rely in the development of their design and in the selection of their means, methods, and construction approaches. The results of any exploration and testing carried out by the Authority, including the subcontracted design teams prior to or during D-B procurement will be included in the reports and made available to all the D-B teams. Bidders for the D-B procurement process may be afforded the opportunity to obtain additional information at locations critical to their planning and design. The Authority, Program Management, and design teams and bidders will jointly review

background understanding of exploration gaps and constraints to help guide in understanding what might be accomplished through supplementary exploration requests.

3.2 GENERAL

For the D-B method of project delivery, a significant issue is the means by which the Authority and D-B team reach agreement about the geotechnical conditions to be expected. Once that agreed definition of expected conditions is reached using the GBR, the issue of differing site conditions (DSC) during construction can be addressed. Under D-B, although the Authority supervises the gathering of the subsurface information, design-specific interpretations for decision making lie with the D-B team. The following text describes the step-by-step means and framework for reaching that agreement on the CHSTP, using a modified process that allows the D-B team to participate in the development of the final GBR. The following three-step approach, adapted from the referenced ASCE 2007 guidelines, is planned for the CHSTP:

Step 1 - GBR-B - On the basis of the site exploration program and preliminary design, the Authority (through its geotechnical and design team) prepares a GBR for Bidding (GBR-B). The focus of this document is the physical nature of the subsurface conditions likely to be encountered, consistent with the layouts and geometries represented in the preliminary design. In this manner, all D-B teams are provided with the same set of physical baseline conditions to be used in their design and construction planning. The document will:

- Describe the basis for the preliminary designs provided by the Authority's design team.
- Provide key baselines of anticipated physical conditions consistent with the exploration program and other relevant construction.
- To the extent desired by the Authority or required by third-party constraints, mandate or preclude the use of certain equipment, means, and methods.

The degree to which the GBR-B provides behavioral baselines will be a function of the level of specificity in the preliminary design. It would be inappropriate for the design team to address behavioral issues in detail, because such issues will be closely linked to the equipment, means, and methods selected by each D-B team. Different construction approaches may warrant different geotechnical considerations and therefore may warrant different behavioral baselines. Some examples are provided for illustration.

In order to facilitate the comparison of documents from multiple teams, a common format is achieved by having the GBR-B prepared with discrete sections of the report left blank. The blanks contain annotations prompting bidders to address these specific issues and behavioral aspects consistent with their choice of equipment, means, and methods.

The Authority will update the GBR-B during the bid process to reflect the results of any additional exploration and testing carried out by the Authority during that time.

Step 2 - GBR-C - As a part of their detailed design and construction planning process, each D-B team will interpret the various baselines expressed in the GBR-B, consider those baselines in the development of their design and construction approaches, and fill in the gaps and blanks in the GBR-B accordingly. Consideration or clarifications suggested by each D-B team are captured in the track-change mode of most computerized word processing software programs. In its completed form, the GBR for Construction (GBR-C) will reflect the physical baselines established by the Authority and its design team (as augmented by any supplemental exploration) and as clarified or modified by the D-B team, and the behavioral baselines described by the D-B team consistent with its design approach, equipment, means, and methods.

Step 3 - Review and Negotiation - As a part of the negotiation process, the Authority will have the opportunity to review each D-B team's GBR-C for concurrence and reasonableness. If, in the Authority's (or its design team's) opinion, the baseline assumptions prepared by a particular team are judged to be optimistic, vague, or otherwise incompatible with statements in the GBR-B, the Authority will seek clarifications through discussion with that team. If those clarifications have an

influence on the cost of the work, the D-B team will be given the opportunity to revise their pricing, adjust the payment terms or provisions, or a combination thereof. The Authority may also choose to carry out such negotiations with more than one D-B team. After the Authority and the successful D-B team agree on such changes, the modified GBR-C supersedes the GBR-B and is incorporated into the D-B contract. From that point forward, its use and function is similar to that for a GBR within the traditional contractual framework.

3.3 ROLES AND RESPONSIBILITIES

The positions and titles of geo-professionals (geologic and geotechnical practitioners) defined in this section are specific to registered professionals in California. A summary of the various roles and responsibilities of the CHSTP parties pertaining to the GBR is listed as follows:

The Authority, along with the Program Management Team, will:

- Participate in the process of setting baselines, both to understand the risks and risk allocation and to fully understand and approve the baseline statements.
- Thoroughly review and understand the various iterations during GBR development, including the review of D-B GBR-C submittals.
- Understand the vagaries of subsurface construction and maintain an adequate reserve fund until all potential risks have been adequately addressed.
- Provide sufficient allowance during construction for adequate documentation of the actual conditions so that the parties can agree on the conditions that were encountered and the circumstances under which they were encountered.
- Participate in selection of the Disputes Review Board.
- Promptly compensate the Contractor for valid DSC claims.
- Provide adequate schedule and funding for geotechnical exploration and for preparation and review of the GBR.

The design teams (Geotechnical Engineer – GE, and Certified Engineering Geologist - CEG, and design engineer) will:

- Prepare interpretations of the data that address design and construction concerns for geotechnically feasible design options.
- Provide geotechnical and design engineers experienced in the appropriate type of design and construction to prepare and review the plans, specifications, and GBR.
- Inform and educate the Authority as to the purpose and use of baselines.
- Write clear, concise, definitive, and realistic baselines that are compatible with the drawings and specifications.
- Explain baselines that are different than indicated by the data.
- Explain the baseline statements and their consequences to the Authority and the contractor.
- Write baselines that can be objectively evaluated.
- Indicate how baseline conditions will be measured and evaluated in the field.
- Provide geotechnical engineers and engineering geologists experienced in site investigations, data collection, and report preparation for the type of construction project being undertaken.

Under D-B procurement, the Program Management team will:

- Provide a thorough review of the various GBR-C documents from the D-B teams.
- Explain to the Authority any differences that may exist between the different proposals and their relative risks and/or cost impacts to the CHSTP.
- Assist the Authority in negotiating agreeable wording in what will become the standing GBR to the D-B contract.

The D-B Contractor team shall:

- Seek clarification of unclear contractual provisions before bid.
- Bid the work with a clear understanding of the GBR-B information, the contractual baselines, and his interpretation of the anticipated geotechnical conditions to be presented in a draft GBR-C to be submitted as part of the bid.
- Bid the work with full consideration of the available geologic data in the GDR information if the bid is based on innovative or unusual equipment, means or methods, or if the bid is below the baseline(s).
- Share the GBR-B and GDR information and interpretation of ground conditions with its major equipment suppliers, subcontractors, design consultants, and materials suppliers.
- Understand and accept the level of risk and its consequences associated with his bid assumptions that are less adverse than the baselines.
- Accept the responsibility for selection of means and methods of construction and their impact on ground performance and construction cost, schedule, and risk.
- Provide means, methods, equipment consistent with the baseline conditions, and other indications in the Contract Documents.
- Promptly make required adjustments if the initially selected means and methods are inappropriate.
- Retain its own design team to assist with preparation of the GBR-C and, if required, help negotiate and finalize the standing GBR.
- Participate in selection of the disputes review board.

The Construction Manager (if separate from the Program Manager) will:

- Be given the opportunity to participate in the review of the GBR-C during its preparation.
- Fully document the actual conditions encountered (particularly compared to those described in the baselines) and the cost, schedule, and risk impacts of such conditions on the construction.
- Carefully and thoroughly evaluate DSC claims submitted by the contractor.
- Acknowledge the existence of, and encourage the Authority to promptly compensate the contractor for, valid DSCs.
- When appropriate, firmly and convincingly explain to the Contractor why a particular DSC claim is not valid.

The Dispute Adjudicators, if called upon, shall:

- Make interpretations using the Contract as a whole, and in the event of conflict respect the contractual hierarchy of the Contract Documents.
- Apply the baselines as stated in the GBR-C, e.g., refrain from invoking judgments that conflict with stated baselines.
- Take into account the influence of the Contractor's means and methods, workmanship, and efficiency on ground behavior and overall performance/progress (cost and schedule).
- Recommend entitlement for conditions more adverse than the baselines only if they have resulted in material additional costs and/or schedule delays to the Contractor.
- Deny the merit of claims if encountered conditions are shown to be consistent with or less adverse than the conditions described in the GBR-C.

3.4 COMMENTARY ON STANDARDS AND KEY REFERENCES

This TM presents standards and standard practices addressing geotechnical reports to achieve the guiding principles of the referenced policies. Deviations from the standards and/or guidelines should be justified, and impacts on risk management, quality and efficiency, construction cost, and schedule should be addressed. The extent of geotechnical reports shall consider the engineering design needs and amount of information necessary to reduce project bid costs, and construction claims. The extent of geotechnical reports will be specific to project features and shall be determined based on the guidelines provided herein.

The primary reference document by ASCE for geotechnical reports is considered the most applicable guideline document for the HST project and projects of similar scope and scale, including federal transportation projects. The Caltrans guideline documents for reports and Federal Highway Administration (FHWA) checklist document are also applicable, although their use is primarily limited to highway- and bridge-type projects. While many of CHSTP features are somewhat similar to those for highway projects or other commercial and commuter rail projects, some specialized features and other aspects of the CHSTP, including project delivery for such major heavy-civil infrastructure works, require higher standards in some areas.

4.0 SUMMARY AND RECOMMENDATIONS

The geotechnical reports are required to have both design-related issues (basis for design) and construction issues as the primary points of focus. The critical elements of the reports deemed necessary for the CHSTP are described in Section 6 of this TM.

5.0 SOURCE INFORMATION AND REFERENCES

The development of the geotechnical report requirements was based on a review and assessment of available information, including the following:

1. American Society of Civil Engineers (ASCE) reference titled "Geotechnical Baseline Reports for Construction – Suggested Guidelines," ASCE 2007
2. Caltrans, Guidelines for Preparing Geotechnical Design Reports, version 1.3 December 2006
3. Caltrans, Guidelines for Structures Foundations Reports, version 2.0 March 2006
4. FHWA, Checklist and Guidelines for Review of Geotechnical Reports and Preliminary Plans and Specifications, FHWA-ED-88-053, 1988, revised February 2003

6.0 DESIGN MANUAL CRITERIA

6.1 GEOTECHNICAL REPORTS

The primary documents for the geotechnical discipline include the Geotechnical Baseline Report (GBR), Geotechnical Data Report (GDR), and Final Geotechnical Design Reports. A summary of the typical contents of these reports is provided in the following sections.

6.1.1 Geotechnical Baseline Reports

The listed elements for GBR reports are adapted from the primary reference document by ASCE.

Introduction

- Project name
- Project owner
- Design team (and design review board, if any)
- Purpose of report; organization of report
- Contractual precedence relative to the GDR and other contract documents (refer to the General Conditions)
- Project constraints and latitudes

Project Description

- Project location
- Project type and purpose
- Physical setting, topography, and existing man-made features
- Summary of key project features (dimensions, lengths, cross sections, shapes, orientations, support types, lining types, required construction sequences)
- Reference to specific specification sections and drawings to avoid repeating information from other contract documents in the GBR

Sources of Geologic and Geotechnical Information

- Reference to GDR
- Designated other available geologic and geotechnical reports
- Historical precedence for earlier sources of information

Project Geologic Setting

- Brief overview of geologic and groundwater setting, origin of deposits, with cross reference to GDR text, maps, and figures
- Brief overview of site exploration and testing programs, avoiding unnecessary repetition of GDR text
- Surface development and topographic and environmental conditions affecting project layout
- Typical surficial exposures and outcrops
- Geologic profile along tunnel alignment(s) showing generalized stratigraphy and rock/soil units, including stick logs to indicate drill hole locations, depths, and orientations

Previous Construction Experience (key points only in GBR if detailed in GDR)

- Nearby relevant projects
- Relevant features of past projects, with focus on excavation methods, ground behavior, groundwater conditions, and ground support methods
- Summary of problems during construction and how they were overcome (with qualifiers as appropriate)

- Conditions and circumstances in nearby projects that may be misleading and why

Ground Characterization

- Physical characteristic and occurrences of each distinguishable rock or soil unit, including fill, natural soils, and bedrock; describing degree of weathering/alteration; including near-surface units for foundations/pipelines
- Groundwater conditions, depth to water table, perched water, confined aquifers and hydrostatic pressures, pH, and other key groundwater chemistry details
- Soil/rock and groundwater contamination, including disposal requirements
- Laboratory and field test results presented in histogram (or some other suitable) format grouped according to each pertinent distinguishable rock or soil unit, including reference to tabular summaries contained in the GDR
- Ranges and values for baseline purposes; explanations for why the histogram distributions (or other presentations) should be considered representative of the range of properties to be encountered, and if not, why not; rationale for selecting the baseline values and ranges
- Blow count data, including correlation factors used to adjust blow counts to Standard Penetration Test (SPT) values, if applicable
- Presence of boulders and other obstructions; baselines for number, frequency (i.e., random or concentrated along geologic contacts), size, and strength
- Bulking/swell factors and soil compaction factors
- Baseline descriptions of the depths/thicknesses or various lengths or percentages of each pertinent distinguishable ground type or stratum to be encountered during excavation; properties of each ground type; cross references to information contained in the drawings or specifications
- Values of ground mass permeability, including direct and indirect measurements of permeability values, with reference to tabular summaries contained in the GDR; basis for any potential occurrence of large localized inflows not indicated by ground mass permeability values
- For tunneling / tunnel boring machine (TBM) reaches, interpretations of rock mass properties that will be relevant to boreability and cutter-wear estimates for each of the distinguishable rock types, including test results that might affect their performance (avoiding explicit penetration rate estimates or advance rate estimates)

Design Considerations – Tunnels and Shafts

- Description of ground classification systems utilized for design purposes, including ground behavior nomenclature
- Criteria and methodologies used for the design of ground support and ground stabilization systems, including ground loadings (or reference the drawings/ specifications)
- Criteria and basis for design of final linings (or reference to drawings/specifications)
- Environmental performance considerations such as limitations on settlement and lowering of groundwater levels (or reference in specifications)
- The manner in which different support requirements have been developed for different ground types and, if required, the protocol to be followed in the field for determination of ground support types for payment; reference to specifications for detailed description ground support methods/sequences
- The rationale for ground performance instrumentation to be included in the drawings and specifications
- Influence of stress concentrations at intersections

- Slope stability issues at tunnel portals
- Seismic considerations in selection of final ground support requirements
- Role of groundwater in final ground support design, i.e., drained or undrained

Design Considerations – Other Excavations and Foundations

- Criteria and methodologies used for the design of retaining walls and excavation support systems, including lateral earth pressure diagrams (or reference in drawings/ specifications) and the need to control deflections/deformations, and bearing pressures
- Feasible excavation support systems
- Minimum pile tip elevations for deep foundations
- Refusal criteria for driven piles
- Allowable skin friction for tiebacks
- Environmental considerations such as limitations on settlement and lowering of groundwater levels (or in specifications)
- Rationale for instrumentation/monitoring shown in the drawings and specifications
- Embankment fill and grading/earthwork criteria

Construction Considerations – Tunnels and Shafts

- Anticipated ground behavior in response to construction operations within each soil and rock unit
- Required sequences of construction (or in drawings/specifications)
- Specific anticipated construction difficulties
- Rationale for requirements contained in the specifications that either constrain means and methods considered by the contractor or prescribing specific means and methods (e.g., the required use of an earth pressure balance (EPB) or slurry shield)
- The rationale for baseline estimates of groundwater inflows to be encountered during construction, with baselines for sustained inflows at the heading, flush inflows at the heading, and cumulative sustained groundwater inflows to be pumped at the portal or shaft
- The rationale behind ground improvement techniques and groundwater control methods included in the contract
- Potential sources of delay, such as groundwater inflows, shears and faults, boulders, logs, tiebacks, buried utilities, other man-made obstructions, gases, contaminated soils and groundwater, hot water, hot rock, etc.

Construction Considerations – Other Excavations and Foundations

- Anticipated ground behavior in response to required construction operations within each soil and rock unit
- Rippability of rock, till, caliche, or other hard materials, and other excavation considerations including blasting requirements/limitations
- Need for groundwater control and feasible groundwater control methods
- Casing requirements for drilled shafts
- Specific anticipated construction difficulties
- Rationale for requirements contained in the specifications that either constrain means and methods considered by the contractor or prescribe specific means and methods
- The rationale for baseline estimates of groundwater inflows to be encountered during construction, with baselines for sustained inflows to be pumped from the excavation
- The rationale behind ground improvement techniques and groundwater control methods included in the contract

- Potential sources of delay, such as groundwater inflows, shears and faults, boulders, buried utilities, manmade obstructions, gases, or contaminated soils or groundwater
- Acceptable fill and backfill material, and compaction requirements

6.1.2 Geotechnical Data Reports

The listed elements for typical GDR reports are adapted from the primary reference documents by the Federal Highway Administration (FHWA), Caltrans, and TM 2.9.1, Geotechnical Investigation Guidelines.

I. Executive Summary

II. Introduction
   - A. Project Description
   - B. Purpose and Scope
   - C. Available Data and Information
   - D. Report Organization

III. Geologic Setting
   - A. General
   - B. Faulting

IV. Seismic Setting
   - A. General Seismic Setting
   - B. Fault Rupture Displacement
   - C. Soil Profile (Site Class) Types, per NEHRP
   - D. Seismic Design Criteria
   - E. Seismic Design Ground Motions

V. Hydrogeologic Setting
   - A. Regional Cross Sections
   - B. Major Aquitards
   - C. Regional Water Levels
   - D. Land Subsidence
   - E. Artesian Conditions
   - F. Presence of Gas
   - G. Groundwater Chemistry and Corrosion Potential

VI. Field Investigations
   - A. Introduction
     1. 15% and 30% Designs
     2. Organizations of Team
     3. Field Manual
     4. Project Restrictions
   - B. Cone Penetration Testing Program
     1. Conventional CPTs
        - a. Equipment
        - b. Procedures
        - c. Locations
        - d. Results
     2. Seismic CPTs

a. Equipment
b. Procedures
c. Locations
d. Results

C. Exploratory Boring Program
1. Overview
2. Drill Rig and Hammer Types
3. Sampling Methods and Equipment
a. Sampler Types
b. Sampling Interval
4. Hand-Held Field Tests
5. Groundwater Level Measurements
6. Sample Handling
7. Borehole Completion and Abandonment
8. Boring Log Organization and Presentation
9. Standard Penetration Tests (SPT)
10. Extruded Boring Logs
11. SPT Energy Calibration
12. Air and Vapor Monitoring
13. Borehole Water Pressure Tests for Bedrock (Fracture) Permeability

3. Hydropunch Testing
a. Equipment
b. Procedures
c. Locations
d. Results
4. Dissipation Testing
a. Equipment
b. Procedures
c. Locations
d. Results
5. CPT Completion and Abandonment

D. Downhole Geophysical Logging
1. Field Procedures
2. Frequency of Testing
3. Results

E. Field Vane Shear Testing
1. Field Procedures
2. Frequency of Testing
3. Results

F. Pressuremeter Testing
1. Field Procedures
2. Frequency of Testing
3. Results

- G. Vibrating Wire Piezometers
  1. Field Procedures
  2. Frequency of Testing
  3. Results
- H. Observation Wells
  1. Field Procedures
  2. Frequency of Testing
  3. Results
- I. Pumping Tests and Slug Testing
  1. Field Procedures
  2. Frequency of Testing
  3. Results

VII Laboratory Investigations

- A. Introduction
  1. Laboratory Visual Classification
  2. Moisture Content
  3. Unit Weight
  4. Specific Gravity
  5. Sieve and Hydrometer Analysis
  6. Materials Finer than No. 200 Sieve
  7. Atterberg Limits
  8. Shear Strength
  9. Expansion Index
  10. Consolidation
  11. Hydraulic Conductivity
  12. Rock Quality Designation (RQD)
  13. Shear Strength Testing of Rock Samples
  14. Brazilian Test (Indirect Splitting Tensile Test) on Rock
  15. Point Load Strength Index Testing on Rock
  16. Slake Durability (of Weak Rock Samples)
- B. Specialty Testing
  1. Shipping and X-ray
  2. Constant Rate of Strain Consolidation Tests
  3. Consolidated Drained Triaxial Tests
  4. Static Direct Simple Shear Tests
  5. K_0-Consolidated Undrained Triaxial Compression and Extension Tests
  6. K_0-Consolidated Undrained Triaxial Compression (Bishop Method) Tests
- C. Corrosion Testing

VIII. Surface Conditions and Subsurface (Soil, Rock, and Groundwater) Conditions along the CHST Alignment

- A. Surface Conditions and Physical Setting
- B. Generalized Subsurface Conditions
  1. Geologic Deposits
  2. Applicable Geotechnical Subsurface Information

3. Material Sources
4. Groundwater Table Information and Hydrogeology
5. Air and Vapor Monitoring

C. Detailed Stratigraphy (Soil and Bedrock)
1. Geotechnical Study Section 1: Sta. __ to Sta. ___
2. Geotechnical Study Section 2: Sta. __ to Sta. ___
3. Geotechnical Study Section 3: Sta. __ to Sta. ___
4. Geotechnical Study Section 4: Sta. __ to Sta. ___
5. Geotechnical Study Section 5: Sta. __ to Sta. ___

D. Geotechnical Properties – Soil and Bedrock
1. Undrained Shear Strength
   a Field Vane Shear Tests
   b. Pressuremeter Tests
   c. CPT Undrained Shear Strength Calibration and Results
   d. Triaxial Tests
   e. Laboratory Static Direct Simple Shear Tests
2. Effective Shear Strength Parameters
   a. Pressuremeter Tests
   b. CPT Undrained Shear Strength Calibration and Results
   c. SPT Blow Counts
3. Compressibility, Load History, and Hydraulic Conductivity
   a. Consolidation Tests
   b. At-Rest Earth Pressure Coefficient
   c. Coefficient of Hydraulic Permeability
4. Stress-Strain Parameters
   a. Initial Tangent Shear Modulus
   b. Secant Modulus
   c. Small-Strain Shear and Compression Velocities (Poisson's Ratio)
5. Rock Parameters
   a. Shear Strength
   b. Durability
   c. Unit Weight
   d. Rock Mass Rating
   e. Bedrock Discontinuities
   f. Geological Strength Index

IX. Limitations

X. References

6.1.3 Final Geotechnical Design Reports

The listed elements for final geotechnical design reports are adapted from the primary reference documents by FHWA, Caltrans, and TM 9.2.1, Geotechnical Investigation Guidelines.

Final geotechnical design reports should, at a minimum, contain the following typical elements though not specifically organized in this format:

1. <u>A general description</u> of the project, project elements, and project background should be included.

2. Project site surface conditions and current use should be included.
3. Regional and site geology - This section should describe the site stress history and depositional/erosional history, bedrock and soil geologic units, etc.
4. Regional and site seismicity - This section should identify potential source zones, potential magnitude of shaking, frequency, historical activity, and location of nearby faults. This section is generally only included in reports addressing structural elements (e.g., bridges, walls, marine terminal structures), and major earthwork projects.
5. A summary of the site data available from project or site records (e.g., final construction records for previous construction activity at the site, as-built bridge or other structure layouts, existing test hole logs, geologic maps, previous or current geologic reconnaissance results) should be included.
6. A summary of the field exploration conducted, if applicable, should be included. Here, a description of the methods and standards used is provided, as well as a summary of the number and types of explorations that were conducted. Include also a description of any field instrumentation installed and its purpose. Refer to the detailed logs located in the report appendices.
7. A summary of the laboratory testing conducted, if applicable, should be included. Again, a description of the methods and standards used is provided, as well as a summary of the number and types of tests that were conducted. Refer to the detailed laboratory test results in the report appendices.
8. Project Soil/Rock Conditions - This section should include not only a description of the soil/rock units encountered, but also how the units tie into the site geology. Groundwater conditions should also be described here, including the identification of any confined aquifers, artesian pressures, perched water tables, and potential seasonal variations, if known, any influences on the groundwater levels observed, and direction and gradient of groundwater, if known. If rock slopes are present, discuss rock structure, including the results of any field structure mapping (use photographs as needed), joint condition, rock strength, potential for seepage, etc. These descriptions of soil and rock conditions should be, in general, illustrated with subsurface profiles (i.e., parallel to alignment centerline) and cross sections (i.e., perpendicular to alignment centerline) of the key project features. A subsurface profile or cross section is defined as an illustration that assists the reader of the geotechnical report to visualize the spatial distribution of the soil and rock units encountered in the borings and probes for a given project feature (e.g., structure, cut, fill, landslide). As such, the profile or cross section will contain the existing and proposed ground line, the structure profile or cross section if one is present, the boring logs (including SPT values, soil/rock units, etc.), and the location of any water tables. Interpretive information contained in these illustrations should be kept to a minimum. What appears to be the same soil or rock unit in adjacent borings should not be connected together with stratification lines unless that stratification is reasonably certain. The potential for variability in the stratification shall be conveyed in the report, if a detailed stratification is provided. In general, geologic interpretations should not be included in the profile or cross section but should be discussed more generally in the report. A subsurface profile should always be provided for bridges, tunnels, and other significant structures. For retaining walls, subsurface profiles should always be provided for soil nail walls, anchored walls, non-gravity cantilever walls, and all other walls in which there is more than one boring along the length of the wall. For other wall situations, judgment may be applied to decide whether or not a subsurface profile is needed. For cuts, fills, and landslides, soil profiles should be provided for features of significant length where multiple borings along the length of the feature are present. Subsurface cross sections should always be provided for landslide and for cuts, fills, structures, and walls that are large enough in cross section to warrant multiple borings to define the subsurface cross section.
9. Summary of geological hazards identified and their impact on the project design (e.g., landslides, rockfall, debris flows, liquefaction, soft ground or otherwise unstable soils, seismic hazards), if any, should be included. Describe the location and extent of the geologic hazard.

10. For analysis of unstable slopes (including existing settlement areas), cuts, and fills, include background regarding the following:
    - Analysis approach
    - Assessment of failure mechanisms
    - Determination of design parameters
    - Any agreements with stakeholders regarding the definition of acceptable level of risk

    Include in this section a description of any back analyses conducted, the results of those analyses, comparison of those results to any laboratory test data obtained, and the conclusions made regarding the parameters that should be used for final design.
11. Analysis and Stability of Tunnels (including mined, bored, and cut-and-cover):
    - Analysis approach and assessment of failure mechanisms
    - Determination of design parameters
12. Geotechnical Recommendations:
    - *Earthwork/sitework* (fill design, cut design, usability of on-site materials as fill: This section should provide embankment design recommendations, if any are present, such as the slope required for stability, any other measures that need to be taken to provide a stable embankment (e.g., geosynthetic reinforcement, wick drains, controlled rate of embankment construction, light-weight materials), embankment settlement magnitude and rate, and the need and extent of removal of any unsuitable materials beneath the proposed fills. Cut design recommendations, if any are present, should also be provided in this section, such as the slope required for stability, seepage and piping control, erosion control measures needed, and any special measures required to provide a stable slope. Regarding usability of on-site materials, soil units should be identified as to their feasibility of use as fill material, discussing the type of fill material for which the on-site soils are feasible, the need for aeration, the effect of weather conditions on its usability, and identification of materials that should be considered as waste. This section should also address site preparation in advance of construction and whether or not there are needs for in-situ ground modification and improvement (e.g., densification, reinforcement and stiffening, grouting).
    - Rock slopes and rock excavation - Such recommendations should include, but are not limited to, stable rock slope, rock bolting/dowelling, and other stabilization requirements, including recommendations to prevent erosion/undermining of intact blocks of rock, internal and external slope drainage requirements, feasible methods of rock removal, etc.
    - Stabilization of unstable slopes (e.g., landslides, rockfall areas, debris flows). - This section should provide a discussion of the mitigation options available and detailed recommendations regarding the most feasible options for mitigating the unstable slope, including a discussion of the advantages, disadvantages, and risks associated with each feasible option.
    - Bridges, tunnels, hydraulic structures, and other structures - This section should provide a discussion of foundation options considered, the recommended foundation options, and the reasons for the selection of the recommended foundation options, foundation design requirements (for strength limit state, ultimate bearing resistance and depth, lateral and uplift resistance; for service limit state, settlement limited bearing and any special design requirements), seismic design parameters and recommendations (e.g., design acceleration coefficient, soil profile type for standard response spectra development, or develop non-standard response spectra, liquefaction mitigation or ground improvement requirements, extreme event limit state bearing, uplift, and lateral resistance, and soil spring values), design considerations for corrosion or scour when applicable, earth pressures on abutments and walls in buried structures, and recommendations regarding bridge approach slabs.
    - Retaining walls and reinforced slopes - This section should provide a discussion of wall/reinforced slope options considered, the recommended wall/reinforced slope

options, and the reasons for the selection of the recommended options, foundation type and design requirements (for strength limit state, ultimate bearing resistance, lateral and uplift resistance if deep foundations selected; for service limit state, settlement limited bearing and any special design requirements), seismic design parameters and recommendations (e.g., design acceleration coefficient, extreme-event limit state bearing, uplift and lateral resistance if deep foundations selected) for all walls except standard plan walls, design considerations for corrosion or scour when applicable and lateral earth pressure parameters (provide full-earth pressure diagram for non-gravity cantilever walls and anchored walls). For non-proprietary walls / reinforced slopes requiring internal stability design (e.g., geosynthetic walls, soil nail walls, all reinforced slopes), provide minimum width for external and overall stability, embedment depth, bearing resistance, and settlement, and also provide soil reinforcement spacing, strength, and length requirements in addition to dimensions to meet external stability requirements. For proprietary walls, provide minimum width for overall stability, embedment depth, bearing resistance, settlement, and design parameters for determining earth pressures. For anchored walls, provide achievable anchor capacity, no load zone dimensions, and design earth pressure distribution.

- <u>Infiltration/detention facilities</u> - This section should provide recommendations regarding infiltration rate, impact of infiltration on adjacent facilities, effect of infiltration on slope stability if the facility is located on a slope, stability of slopes within the pond, and foundation-bearing resistance and lateral earth pressures (vaults only).

13. <u>Long-term or construction monitoring needs</u> - In this section, provide recommendations on the types of instrumentation needed to evaluate long-term performance or to provide control during construction, the reading schedule required, how the data should be used to control construction or to evaluate long-term performance, and the zone of influence for each instrument.
14. <u>Construction considerations</u> - Address issues of construction staging, shoring needs and potential installation difficulties, temporary slopes, potential foundation installation problems, earthwork constructability issues, dewatering, etc.
15. <u>Appendices</u> - Typical appendices should include design charts for foundation bearing and uplift, P-Y curve input data, design detail figures, layouts showing boring locations relative to the project features and stationing, subsurface profiles and typical cross sections that illustrate subsurface stratigraphy at key locations, all boring logs used for the project design (includes older borings as well as new borings), a boring log legend for each type of log, laboratory and field test data obtained, instrumentation measurement results, and special provisions needed.

The detail contained in each of these sections listed above will depend on the size and complexity of the project elements and subsurface conditions. In some cases, design memoranda that do not contain all of the elements described above may be developed prior to developing a final geotechnical report for the project.